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NIST Research Reports

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NIST Special Publication 761

NATIONAL INSTITUTE OF STANDARDS &
TECHNOLOGY
Research Information Center
Gaithersburg, MD 20899

On the cover: Diamond films can play an important role in many advanced technologies. The micrograph on the cover shows individual diamond particles that have been deposited on a silicon wafer in research at NIST. See article on page 24.

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NIST Research Reports

U.S. DEPARTMENT OF COMMERCE
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The National Bureau of Standards became the National Institute of Standards and Technology on August 23, 1988, under the Omnibus Trade and Competitiveness Act. NIST retains all NBS functions. Its new programs will encourage improved use of technology by U.S. industry.

Research Update

Computer Security Board Named

NIST has appointed a 12-member board to advise NIST and the Secretary of Commerce on security and privacy issues pertaining to federal computer systems. The board was established as part of the Computer Security Act of 1987. The act gives NIST responsibility for developing standards and guidelines needed to protect the security and privacy of sensitive unclassified information in federal computer systems.

The board's chairperson is the director of the NIST National Computer Systems Laboratory, James H. Burrows. The board members are: Bill D. Colvin, National Aeronautics and Space Administration; Roger M. Cooper, U.S. Department of the Treasury; Robert H. Courtney, Jr., RCI Inc.; John A. Kuyers, Ernst and Whinney; Steven B. Lipner, Digital Equipment Corporation; Rhoda R. Mancher, Veterans Administration; Robert Morris, National Security Agency; Jack W. Simpson, Mead Data Central; Walter W. Straub, Rainbow Technologies, Inc.; Willis H. Ware, The Rand Corporation; Larry L. Wills, International Business Machines Corporation; and Eddie L. Zeitler, Security Pacific National Bank.

CD-ROM Speech Database Available

As part of its speech recognition research to help computers become better listeners, NIST researchers have produced the first speech database in this country in CD-ROM (compact disc-read only memory) format. The database consists of digitized speech data for 420 talkers speaking 4,200 sentences. NIST researchers have been working with private industry and the Defense Advanced Research Projects Agency to develop ways such as this database to measure the performance of speech recognition systems. Texas Instruments, the Massachusetts Institute of Technology, and SRI International collaborated with NIST to produce this CD-ROM database. A limited number of discs are available from David Pallett, NIST, A216 Technology Bldg., Gaithersburg, MD 20899, 301/975-2935.

Volt, Ohm Standards To Change

National representatives of the world's weights and measures community met recently in Sèvres, France, to adopt new conventional values for the Josephson constant and the von Klitzing constant. These are the fundamental physical constants required to determine operational values of the volt, using the AC Josephson effect, and the ohm, using the quantum Hall effect. The changes, approved by the International Committee of Weights and Measures (CIPM), will take effect January 1, 1990. All industrial nations will share, for the first time, a common practical basis for measuring voltage and resistance.

Prior to this, there was a difference of approximately 1.2 parts per million (ppm) between the U.S. voltage standard and that of most European countries purely because of differences in the way the national standards were maintained. With the advent of modern, high-precision voltmeters, such differences have become increasingly significant to U.S. firms seeking to export high-precision equipment. For the United States, the new values mean that NIST will adjust the U.S. voltage standard by about 9.3 ppm, and the U.S. resistance standard by about 1.7 ppm. Precision electrical measuring instruments will have to be adjusted or recalibrated to maintain consistency with the new national standards.

Test Instrument To Detect Computer Flaws Patented

Researchers from NIST and private industry recently were granted a patent (no. 4,764,863) for a test instrument designed to verify the correctness of information exchanges between large electronic devices. The instrument offers the designers, builders, and users of complex computer systems a powerful tool for tracking down subtle flaws in equipment in a way previously not possible.

Most flaw-detecting instruments are programmed to trigger only when certain, predetermined events happen. This instrument can be programmed with an idealized model of a properly operating system; it then monitors the system until something out of the ordinary is encountered. At that point, recording circuits are triggered to memorize the anomaly.

The inventors of this instrument are Robert B.J. Warnar, George G. Nacht, Philip Gaudette, and Arthur W. Holt (retired) of NIST and Lee J. Silverthorn of Software Resources, Inc., Paradise Valley, Ariz. For licensing information, contact Office of Federal Patent Licensing, National Technical Information Service, Springfield, VA 22161, 703/487-4732.

Software Helps Select Patrol Vehicles

A computer software program that police fleet managers can use to select patrol vehicles best suited to their needs has been written by a NIST economist. The program, called AutoBid, was sponsored by the National Institute of Justice (NIJ). AutoBid is based on Michigan State Police patrol vehicle performance test data and runs on an MS-DOS(tm)-based personal computer with at least 384K

bytes of RAM. AutoBid offers users two methods of assessing vehicles: performance or value. Performance is based on vehicle test scores alone, ranking vehicles independently of cost. The value method is based on both vehicle cost and test scores. The AutoBid program is available to law enforcement agencies from the NIJ's Technology Assessment Program Information Center, Box 6000, Rockville, MD 20850.

Participants Wanted for OSI, ISDN Security Program

NIST is inviting companies and other government agencies to join in a cooperative research program relating to security and management of computer networks that use the Open Systems Interconnection (OSI) architecture or Integrated Services Digital Network (ISDN) communications services. NIST is looking for participants to provide funding, equipment, and/or staff. A major goal of the program is to expedite the development and commercial availability of OSI and ISDN security products.

As part of the program, NIST will provide a facility to define, develop, and test systems for a range of telecommunications, network management, and security services in a distributed information processing environment. For further details, write to NIST, B151 Technology Bldg., Gaithersburg, MD 20899, Attn: Integrated OSI, ISDN, and Security Program.

Clarification

NIST has been involved in a collaborative effort to automate the traditional radiometric method of DNA sequencing. An article in the October 1988 issue of *NIST Research Reports*, which described this work, contained statements that were critical of new sequencing methods that use fluorescent dyes to label the DNA fragments. In fact, these methods also have been automated, and instruments with very high performance capability and high throughput capacity are commercially available. NIST does not recommend any particular procedure or product for use in automated DNA sequencing and has not done the comparative laboratory testing necessary for a critical evaluation of the radiometric versus fluorescence methods.

New Materials Can Help Gauge Coal Sulfur Content

Because sulfur emissions from coal-fired industrial plants are regulated by environmental agencies, it is important for coal and utility companies to know how much sulfur is contained in a given coal batch. Likewise, coal companies and their customers need accurate determinations of sulfur and ash content along with calorific value to set fair tonnage prices of coal shipments. A new NIST Standard Reference Material (SRM) can help boost the accuracy of all these measurements by allowing evaluation of laboratory methods and calibration of instruments used in coal analysis.

The SRM, which consists of a 50-gram bottle of bituminous coal, is certified for its sulfur and ash content as well as its calorific value. Also included are non-certified values of 23 other elements. The new material (SRM 2692) costs $102 and is available from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-6776.

Bulk Asbestos Standard Available

A set of asbestos Standard Reference Materials (SRM's) is available for laboratories involved in the National Voluntary Laboratory Accreditation Program on Bulk Asbestos and for others concerned with asbestos abatement projects. The SRM's are typical of asbestos types found in bulk samples during routine inspections of building materials. The set consists of three common mine-grade asbestos materials and one synthetic glass fiber sample. The asbestos types are chrysotile, grunerite (amosite), and riebeckite (crocidolite).

The optical properties of the materials have been characterized for use as a primary calibration standard for identifying asbestos types in building materials. The glass fiber sample does not contain asbestos and can be used to check procedures and equipment for contamination that would affect the accuracy and limits of detection of asbestos analysis. SRM 1866, Bulk Asbestos Common, is available for $375 from the Office of Standard Reference Materials, NIST, B311 Chemistry Bldg., Gaithersburg, Md. 20899, 301/975-6776.

New System Tracks Air Flow

Knowing how air flows into, out of, and within a building is important information to those analyzing indoor air quality and energy use. Most techniques currently available either treat the building as a single, well-mixed volume of air or are complex, requiring the use of several different tracer gases. A new technique developed by researchers in the NIST Center for Building Technology uses a single gas to trace airflow between various zones or building areas. In field trials, the technique was quicker and more accurate than any previously used.

Light: The Wave of the Future

Firms in other countries such as Japan have managed to apply photonic technology to useful, attractive, saleable products well before products from our own companies have been able to reach the market. . . . "In a number of areas, Japanese optoelectronic technology is more advanced than the best available in this country. Development by the Japanese of the full potential inherent in photonics could threaten America's leadership in several areas of electronics. . . .

"The promise of optical technology to bring improvements in bandwidth, information processing, information storage, and sensing to the consumer at substantially lower cost must be a major driving force for the commercialization of photonic technology in this country. . . . Development of marketable consumer products based on photonic technology . . . must be a keystone of national strategy. . . ."—Robert M. White, president, National Academy of Engineering, *Photonics: Maintaining Competitiveness in the Information Era,* a National Research Council report.

Whether it's called photonics, optoelectronics, or lightwave technology, this new communications technology has begun to play a significant role in several fields, and it will have a major effect on the U.S. economy.

John W. Lyons, director of the NIST National Engineering Laboratory, offered this insight in testimony before the House Subcommittee on Science, Research and Technology:

"The recent move to optical communications systems is reflected in U.S. purchases of about $1 billion in fiber optic components in 1987 and a worldwide market for these components of about $2.5 billion in 1988. An independent forecast for the world market for optical systems and components is for growth to about $12 billion by the year 2001. This figure compares favorably with the figure of about $10 billion for electronic equipment in the same marketplace today. There is no question but that the telecommunications market is one of the largest sectors of the U.S. economy, and its health has a significant bearing on the overall state of our economy."

...this new communications technology has begun to play a significant role in several fields, and it will have a major effect on the U.S. economy.

Already the nation's major telecommunications companies are routing many telephone calls through optical fibers, tiny strands of glass that can carry more information more efficiently than copper wires. How does it work? Essentially, electrical energy is converted by lasers to lightwaves which are sent through the hair-thin strands of glass. For example, using this technology, the entire contents of the *Encyclopaedia Britannica* can be transmitted in about 2 seconds. That same transmission over a copper telephone line would take nearly 2 *days.*

This technology also has been employed to read disks and has spawned the era of compact disk recordings and optical character readers.

But this is just the beginning. Light coursing through optical fibers has the potential for becoming as commonplace as electrical wiring or electronic integrated circuits. For example, optical fibers may some day connect our homes and offices with switching stations that provide a host of educational services, computer databases, and high-definition television, which is expected to offer sharper pictures and better sound than conventional television. Mainframe computers may be based wholly on optical instead of electronic components, allowing much faster computing speeds than even the fastest of today's supercomputers.

To help to usher in this new era of technology, the National Institute of Standards and Technology is working to provide industry with the required measurement expertise. Already NIST has aided the telecommunications industry by providing characterization and measurements for voluntary industry standards for optical fibers. NIST has also begun to offer basic measurement and calibration services to support this growing industry. (See box on page 6.)

Igor Vayshenker, a NIST electrical engineer, calibrates a commercial test meter used by optical fiber manufacturers to calibrate their own optical power meters.

The focus for optical technology research within NIST is the Electromagnetic Technology Division in Boulder, Colo., where four major projects are under way. Optical fiber metrology and laser power and energy metrology are the two oldest and most advanced programs. More recent additions are programs in optical communication device metrology and optical fiber sensors.

In the past 3 years, the NIST optical technology research program has expanded, principally in the area of components needed for modern telecommunications systems. This expansion includes research on such components as laser diodes, detectors, couplers, modulators, and optical waveguides.

The optical fiber metrology program dates back to 1976, when NIST assigned three scientists to characterize optical fibers in anticipation of their use in the telecommunications industry. In the years since, NIST has worked with the Electronic Industries Association and its associated Telecommunications Industry Association, as well as other organizations, to develop the measurements upon which voluntary industry standards could be based. NIST has provided the measurement basis for 25 industry standards adopted by these voluntary standards groups.

The Electronic Industries Association has said that without the assistance and leadership of this NIST program over the past decade, "the U.S. fiber optics industry would not be in the competitive position it is today."

A current standards-related project concerns the geometry of optical fibers—their roundness, diameter, and the offset between the core and the surrounding glass, called the cladding. A round-robin test of various measurements is under way in the United States to be completed in

Measurement Services for the Telecommunications Industry

NIST offers a total of eight calibration and/or measurement services for laser power and energy meters and optical fiber power meters. NIST develops and maintains the country's national standards for measurement of laser power and energy. It also maintains well-characterized transfer standards, which allow various laser power and energy meters to be compared to the standards. The services offered include:

1. Laser power and energy meter calibration in four series, C, Q, K1, and K2. The wavelength range is 488 nanometers to 10.6 micrometers; the power range is from 1 microwatt to 300 watts, and typical uncertainties range from 0.5 to 3.5 percent.

2. Measurement Assurance Programs (MAP's) for laser power and energy. These programs are available at the same wavelengths and power ranges as the calibration services. For a specified wavelength and power or energy, the appropriate transfer standard is sent from NIST to the MAP participant who calibrates the NIST transfer standard and returns the data and standard to NIST. NIST evaluates the data and returns an intercomparison report to the participant.

3. Optical fiber power meters. These are calibrated using an automated system whereby the test meter and the laboratory standard are alternately exposed to a stable laser source. The laboratory standard is an electrically calibrated pyroelectric radiometer which has been calibrated against the primary standard calorimeter. Measurement capabilities for optical fiber power meters range from 850- to 1550-nanometer wavelengths and 100 microwatts in power. Typical uncertainties range from 0.5 to 1.0 percent.

4. Measurement Assurance Program for optical fiber power meters. NIST maintains a set of calibrated transfer standards which are available for MAP intercomparisons of optical fiber power meters. These transfer standards are calibrated as stated above and at the same wavelengths and power levels.

5. Low-level laser Measurement Assurance Program. NIST has instituted a low-level laser MAP using special silicon and germanium diode detectors to measure pulse energy and peak power of low-level, 1.064-micrometer laser pulses of about 10- to 100-nanosecond duration.

6. Pulsed 10.6-micrometer calibrations. NIST can perform responsivity and energy calibrations on instruments designed to measure pulsed laser radiation at a wavelength of 10.6 micrometers. A transfer standard is used in a beam-splitter arrangement in which a transversely excited atmospheric pressure CO_2 laser is used as the radiation source. Calibrations are performed at pulse widths of 200 nanoseconds and have uncertainties of between 5 and 15 percent.

7. Special tests for laser power and energy meters. NIST performs special laser calibrations or measurements at wavelengths or power levels not already listed. It also performs unique measurements such as impulse response or linearity.

8. Special tests for optical fiber power meters. These are performed on optical fiber power meters at wavelengths and power ranges not previously listed. This category includes power meters using fiber connectors and meters which have small area detectors.

For more information concerning calibrations and measurements, contact Thomas R. Scott, Division 724.02, NIST, Boulder, Colo., 80303 or phone 303/497-3651.

a year. There will also be an intercomparison of European measurements, which is being coordinated by British Telecom Research.

Researchers on this project, under the direction of Douglas L. Franzen, are also making measurements on a new type of fiber—a fluoride glass composition—which has the potential for longer transmissions without the use of repeaters. Current glass fibers are made of fused silica and must have the signal amplified about every 25 miles.

"If it pans out, you could stretch a fiber from the United States to Europe without repeaters," says Franzen. The new fiber will permit longer wavelength transmissions—2 or 3 micrometers versus the present 1.3 or 1.5 micrometers. The fibers are more efficient at these longer wavelengths.

Franzen and his colleagues are developing a complete measurement system to test components for high data rate transmissions. A clear advantage of optical fibers over copper wires is their potential to carry tremendous amounts of data—100 billion bits per second. But this ability is limited by the speed with which conventional electronics and lasers, particularly laser diodes, can be pulsed, or switched on and off. In laboratory tests, the NIST researchers have achieved pulses of nine-trillionths of a second, which translates to a potential carrying capacity of between 10 and 20 billion bits per second. Commercial application of these pulse rates are probable within the next 5 years, Franzen estimates.

"The telecommunications industry wants to increase the carrying capacity of fibers now in the ground by increasing the bit rate," he says. Current carrying capacities of between 1 and 2 billion bits per second are being rapidly eclipsed. "It seems there's a never-ending appetite for more data transmission; high-definition TV will only increase the demand," Franzen continues.

Researchers . . . are also making measurements on a new type of fiber—a fluoride glass composition—which has the potential for longer transmissions without the use of repeaters.

High power and energy measurements of lasers have long been established at NIST, but the growth of the optical fiber communications industry has produced requirements for measurements and calibrations at lower power and energy levels. Within the past year, a group of NIST researchers, headed by Thomas R. Scott, has been calibrating fiber optic power meters for the telecommunications industry. Scott and his colleagues are also working to develop measurement services for linearity, uniformity, and spectral responsivity. "These are needs identified by industry," Scott notes.

To keep abreast of industry's needs, Scott plans to maintain close contact with several telecommunications companies. His group is also working on an improved calorimeter for optical fiber power and energy measurements. It will be based on the same principle as the current standard calorimeter; that is, the calorimeter captures laser beam energy, absorbs it, and converts it to thermal energy. The calorimeter's temperature is monitored and correlated with the amount of laser energy that was put into the calorimeter. This new calorimeter will be especially useful in measuring low levels of power generated by laser diodes.

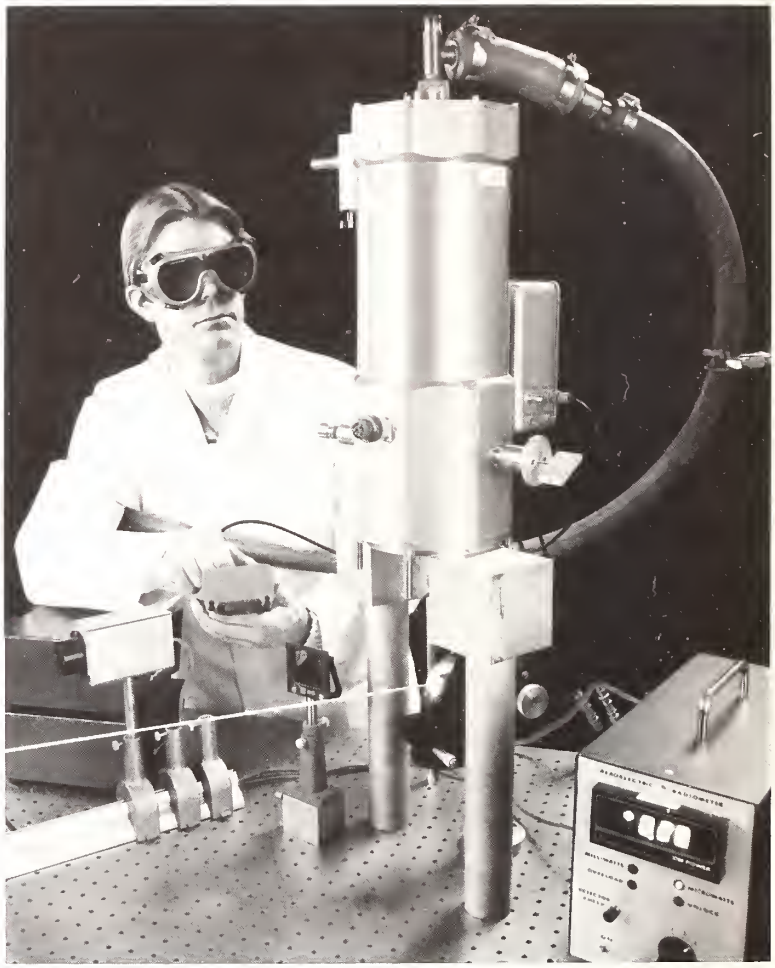
"Our work is being driven by the growth and maturity of fiber optic use by the telecommunications industry," says Scott, adding, "They are using more power meters and they need traceability for that equipment."

The properties of fiber depend on many external parameters, especially mechanical stress, temperature, and magnetic field. These effects can be exploited by using fiber as the sensing element in measurement systems. The advantages include most of the same reasons fibers are being used for communications: size, speed, sensitivity, and, perhaps most importantly, immunity to electromagnetic interference.

The market for all kinds of sensors is growing rapidly and fiber sensors represent an increasing percentage of that market. Some studies have estimated the potential sales for fiber sensors to be as much as $5 billion by the year 2000. The National Academy of Engineering, in the study already cited, declares that "the need for standardization and the demonstration of well-engineered all-optical systems" are the major barriers to the development of this industry.

NIST's optical fiber sensor program, headed by Gordon W. Day, emphasizes the use of fiber for electromagnetic measurements: current, voltage, and magnetic and electric fields. It is helping the fiber sensor industry by developing a good understanding of the components that are used in fiber sensors. It is also helping other government laboratories with specific applications of fiber sensors.

The NIST program had its beginnings in a joint project with Los Alamos National Laboratory. Los Alamos scientists needed to measure very large (many millions of amperes) pulsed currents. When generated, these currents also generate considerable interference. Optical fiber sensors, because they are nonelectrical, were a potential solution to the interference problem. After several years of detailed study of fiber properties and sensor design and development, fiber current sensors have become part of the standard instrumentation for such measurements.



As part of research to develop an electrically calibrated detector for low-level optical power and energy measurements, physicist Rex Craig adjusts a helium-cooled, electrically calibrated silicon on sapphire bolometer. The device is designed to be operated over a wide range of wavelengths.

The analysis and component characterization studies undertaken during the course of this work led NIST scientists to techniques for using fiber current sensors to measure much smaller currents and to improve their stability and accuracy. These developments should open up new application areas. For example, NIST recently completed a study of the potential application of current and voltage sensors in the electric power industry, where accuracy is a paramount concern.

As a follow-up to this study, the NIST Electrosystems Division in Gaithersburg, Md., in collaboration with the electric power industry, has begun an experimental program to evaluate certain measurements made with optical

sensors versus those made with conventional transducers, such as magnetic current transformers. The goal is to obtain a definitive database that may alleviate concerns about the long-term accuracy and reliability of the optical sensors and, thereby, facilitate their acceptance by the industry.

Presently, in joint programs with NASA and the Navy, NIST scientists in Boulder are studying the use of current and voltage sensors for power monitoring on board aircraft and ships. For the Defense Nuclear Agency, they are studying the application of optical fiber current and magnetic field sensors to high-speed pulse measurements.

A newer NIST program deals with measuring the characteristics of optical waveguides. Many new components and subsystems will be built using optical waveguides, where the refractive index of a material is modified so light flows in channels a few micrometers wide. By getting light to flow in channels, it becomes easier to perform a variety of functions, such as switching, modulating, multiplexing, and coupling—functions similar to those in electronic microcircuits. Individual or integrated devices are needed for these functions, and they, too, need characterization.

NIST researchers, headed by Robert J. Phelan, are in the process of making optical waveguides out of various materials, such as lithium niobate and gallium arsenide. Phelan and his colleagues are also creating detectors and modulators to control the photons. "For any device you can think of in electronics, there's an analog in optics," says Phelan.

The purpose in constructing the various optical components is not to produce commercial products (there are very few now on the market) but to understand the composition and functions of the components so that they can be better measured and characterized. "We're just getting into integrated optics in order to advance the state of measurement art," says Phelan.

..."the need for standardization and the demonstration of well-engineered all-optical systems" are the major barriers to the development of this industry.

He foresees commercial applications in the telecommunications industry, such as local area computer networks where the high data rate to be communicated is best handled through lightwave technology.

Another facet of his group's work is the production and measurement of extremely fast pulses of light. For the potential of optical communication to be fully realized, it will require turning optical devices on and off at the level of trillionths of a second. Phelan has built a detector capable of measuring pulses down to two-trillionths of a second.

There is stiff international competition to develop optical technology. Japan has, perhaps, taken the lead in this area. Among others, British Telecom in Great Britain and AT&T Bell Labs and Bell Core in this country have major research programs. Where all of this will lead is uncertain at the moment, but it is clear that there is the potential for revolutionary changes in communications. And NIST wants to be in a position to give support to the advanced measurement technology that will be involved.

Recently, Phelan received the go-ahead to purchase a million-dollar chemical beam epitaxy system that will allow NIST to grow unique optoelectronic semiconductor chips of indium gallium arsenide phosphide. "We will develop multiple quantum wells to make lasers, modulators, switches, and waveguides. We will be able to control the device structures to a very precise degree," Phelan notes.

Perhaps in the not-too-distant future laser diodes will be as common in our homes as transistors are today. To ensure that we get there, NIST is preparing the measurement base to support a whole new industry. And that is NIST's primary goal—to provide industry with the best measurements in order to produce the best products.

by Fred McGehan
NIST Public Affairs Specialist

New Centers To Aid Industry

The Cleveland Advanced Manufacturing Program in Cleveland, Ohio, Rensselaer Polytechnic Institute in Troy, N.Y., and the University of South Carolina in Columbia, S.C., were selected by the National Institute of Standards and Technology to establish regional manufacturing technology centers to aid small- and medium-sized businesses. The centers will help smaller firms take advantage of some of the recent and dramatic advances in manufacturing technology. Thirty-six non-profit institutions representing various segments of industry, state and local government, and academe applied for the federal support.

"It was not difficult to find qualified organizations. It *was* difficult to narrow the field down to just three," said Raymond G. Kammer, acting director of NIST. NIST selected the three organizations after a National Research Council committee reviewed applications and NIST staff members made site visits to eight of the applicants.

Each new center will:

- inform and educate the industrial firms in its region;
- demonstrate the applicability of advanced technology to these firms;
- actively help firms to evaluate their requirements and to implement newer technologies;
- support workforce training and retraining; and
- share appropriate transfer experiences with others.

The program is intended to accelerate the transfer of manufacturing technology to small- and medium-sized U.S. businesses....

The Cleveland Advanced Manufacturing Program (CAMP) will establish a NIST Regional Manufacturing Technology Center at the Unified Technologies Center, a recently constructed facility for technology demonstration and training in downtown Cleveland on the campus of Cuyahoga Community College. The not-for-profit CAMP emphasizes research, development, technology applications, and training in an area with a very high density of manufacturing activity.

NIST funding will help Rensselaer Polytechnic Institute to establish the Northeast Manufacturing Technology Center, which will concentrate on applying advanced manufacturing technologies to material removal, assembly, and inspection of mechanical components for the automotive, consumer, and electronics industries. The center will take advantage of a New York state extension network and build upon that concept in applying it to similar extension organizations in other northeastern states.

The South Carolina Technology Transfer Cooperative will be established by the University of South Carolina and the state's technical college system to transfer new manufacturing technology to small- and medium-sized metal fabricating companies. Clemson University faculty also will be involved in this NIST Regional Manufacturing Technology Center, which is located in a state that is diversifying its manufacturing economy and

expanding its fabricated metals industry.

"We expect not only to monitor the progress of these centers but to work closely with them. NIST researchers will visit the centers, and we expect the centers' staffs to spend time at our laboratories," said Kammer.

The new NIST Regional Manufacturing Technology Centers have some notable common features, according to Kammer. In each case, the market for their manufacturing support services is well understood and the delivery mechanisms have been well thought out. Educational needs—training and retraining—have been given very high priority. In addition, strong local capabilities exist to adapt manufacturing technologies to the particular needs of local industry. And, importantly, all enjoy excellent state and local industry support.

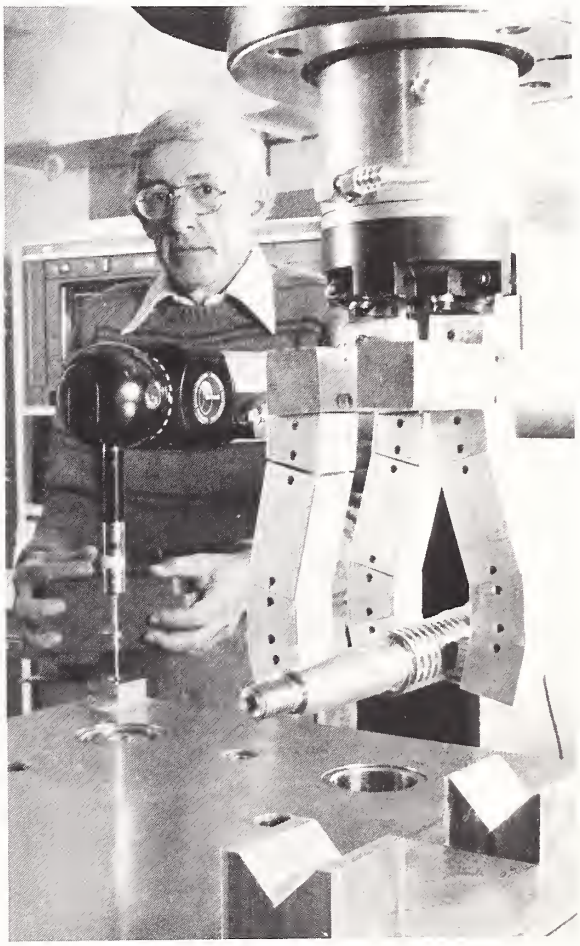
The Regional Manufacturing Technology Centers Program is part of NIST's expanded mission. The Institute is charged with helping U.S. industry be more competitive by adopting productivity- and quality-improving techniques. The program is intended to accelerate the transfer of manufacturing technology to small- and medium-sized U.S. businesses to help these firms to improve their manufacturing capabilities and market competitiveness—an important ingredient to successful international economic competition. Each center will serve the needs of manufacturers located within its region.

One of the major manufacturing technology resources to be used by these new centers in helping companies is the NIST Automated Manufacturing Research Facility (AMRF). This research version of the "factory of the future" has been used by government, industry, and universities for years to advance the state-of-the-art in flexible automated manufacturing, and to perform measurement and standards research needed to make advanced manufacturing techniques more accessible to U.S. companies.

Many advanced manufacturing technologies have been developed and implemented in the AMRF. Although the purpose of the AMRF is research on broad issues such as advanced technologies for making precisely machined parts and standardized interfaces between various types of equipment, there are narrower pieces of new technology that may be transferred separately. The extent of transfer will depend upon the individual needs of the Manufacturing Technology Centers' client businesses.

NIST has established cooperative agreements with the host organizations to provide at least $1.5 million in matching funds for each of the centers. The host organization may count as part of its matching funds dollar contributions from state, county, city, industrial, or other sources. It also may count in-kind contributions of full-time personnel, equipment, and centrally located office, laboratory, and shop floor space directly related to this program.

by Mat Heyman
Chief, NIST Media Liaison



Metrologist Ralph Veale monitors the performance of a robot at the inspection workstation in the NIST Automated Manufacturing Research Facility. The test routine used by the coordinate measuring machine is generated automatically from a computerized description of the part under test, an example of the advanced automation control techniques studied at NIST.

Commercialization of Technology: Whose Job?

The commercialization of technology is receiving unprecedented attention not only in Washington, but also by industry and university policymakers, scientists, and engineers around the country. Let me tell you briefly about one of the changes the federal government has made in order to deal with technology issues. Late in the last session of Congress, legislation was passed establishing an Under Secretary for Technology and a Technology Administration within the Commerce Department.

I believe that this was an essential step in heightening the role of technology within the Department of Commerce and in integrating that role with the considerable economic analysis, trade, and other functions of the department. Such a coordinated effort needs to be put squarely behind U.S. technology-based industry and business. You will notice I said "behind U.S. industry." That implies industry is out front—an issue that I'll return to later.

This article was excerpted from remarks made by Ernest Ambler, Acting Under Secretary for Technology, U.S. Department of Commerce, to the Institute of Electrical and Electronics Engineers' Technology Policy Conference, Washington, D.C., on February 21, 1989.

I think the decision to give the Commerce Department an explicit position and organization for dealing with technology matters reflects an emerging consensus that the state of civilian technology in this country is an issue that we must deal with better. The federal government should have an important role to play in helping industry to improve the applications of civilian technology and, therefore, marketplace performance.

Coming to that conclusion is the easy part. But then determining exactly what this role should be still is not crystal clear. But there is one thing that I think is incontrovertible. It is the job of the private sector to develop and sell goods and services. Government has never been successful in showing industry how to do its job, and there is absolutely no reason to think that will change in the future.

That does not mean the federal government cannot help. It can. But the government's role must be limited and carefully designed to help and not to hinder. Business and industry must get out front, and they must do so in a way that is more cohesive from a national point of view.

It is the job of the private sector to develop and sell goods and services.

That clearly relates to the Commerce Department's broadened technology mission, which is: "to develop and promote federal technology policies and programs to increase U.S. commercial and industrial innovation, productivity,

and growth through consultation and collaboration with U.S. industrial and non-profit sectors." The office of the Under Secretary is a catalyst, a friend, a forum, a listening post, and a voice in Washington for technology-based industry.

One of the first things I did was to draft a charter for a technical advisory board with predominant industrial membership. It is my intention that this board be a central feature of the operations of the Under Secretary.

Now let me give you a little more detail about the new Commerce Technology Administration. It includes three line organizations—the National Institute of Standards and Technology, the National Telecommunications and Information Administration, and the National Technical Information Service.

The two new offices in the Technology Administration are the Office of Technology Policy and the Office of Commercial Affairs. The Policy Office is already carrying out its functions by identifying opportunities or barriers affecting U.S. commercial innovation, quality, productivity, and manufacturing. It is also advocating federal policies and programs to eliminate—across the government—statutory, regulatory, or other barriers to the rapid U.S. commercialization of science and technology.

The Office of Commercial Affairs will have more operational programs. This office encourages the establishment of industry research consortia through joint ventures; works to speed industry's adoption of flexible computer-integrated manufacturing by mostly small- and medium-sized businesses; increases private sector access to federally developed technology by seeking greater industry involvement in, and awareness of, research conducted at federal laboratories; improves the information available to U.S. companies about Japanese science and technology developments; and works closely with the Department of Defense.

But the government's role must be limited and carefully designed to help and not to hinder.

Let me now offer you some reflections after 2 months on this new job. First, there is so much going on in the Commerce Department that relates specifically to technology—with the potential to help U.S. industry.

What we need to do, and what I consider the Under Secretary's reason for being, is to ensure that technological and business facts figure into the larger equation, so that federal decisions that affect our civilian technology and technology-based business enterprises reflect these facts to the greatest extent possible. There clearly is a role for a federal voice that will speak out for U.S. technology-based industries' interest and help forge a national effort.

By the same token, an active federal role does not mean that the federal government should unilaterally design a solution—it should not, and it cannot. I am firmly convinced that the ball is in the private sector's court. The federal government can provide leadership as a convener and must help remove some of the roadblocks to commercializing new technologies. The government must in some cases provide incentives and support generic technology through its own R&D budgets. In all cases, it must listen to and respond to what industry is saying. But, in the final analysis, this country's technological and commercial success rests with industry.

I hope that the industrial community will feel that the mission of this new Technology Administration provides exactly the right environment for it to use as a platform to get the government's attention. I think that the mechanism is now in place for a Department of Commerce that will be more aggressive, more in tune with industry's technological needs. But let me reiterate: Industry must first pull together. Industry must show the government that it is willing to make decisions that allow cooperation and partnership, that it is ready, willing, and able to cooperate among companies and with the government. If it can do that, I think it will find a strong partner in the Commerce Department.

NIST 1990 Budget Proposed

The President's budget proposal to Congress for fiscal year 1990 includes $155.6 million for the National Institute of Standards and Technology. This compares with $159 million appropriated by Congress for FY 1989. Measurement is vital to all segments of the U.S. industrial economy to assure quality and cost-competitiveness of high-technology products and services. The request recognizes NIST's traditional role in providing measurement-related scientific and engineering research to support U.S. industry, government, and science. In addition, the request recognizes NIST's enhanced role under the Omnibus Trade and Competitiveness Act of 1988, which was designed to boost U.S. industry in the world marketplace. Particularly, NIST research is targeted at helping industry accelerate the commercialization of new, high-technology products and services.

■ Included in the request are program increases in several areas:

Chemical Process Control and Quality Assurance ($2.1 million). Chemical measurement technology, standards, and reliable data are crucial to enhance productivity, introduce new technologies, and meet the competitive challenge in a range of international markets. For many emerging technologies, no chemical measurement base exists. This request would add to $400,000 appropriated in FY 1989 and would allow NIST to advance chemical measurement science needed for new, high-technology industries and to improve the quality assurance of chemical measurements.

High-Performance Composites ($1 million). Composites are attractive because of their high strength and stiffness, corrosion resistance, design and manufacturing flexibility, and effectiveness in conserving critical materials. They are an important area of worldwide competition in which the United States is no longer a clear leader. The program at NIST would focus on developing basic information needed to link the microstructure of the material components to their performance characteristics. This increase would mean a total of $3 million would be available for the program in FY 1990.

Lightwave Measurement Technology—Fiber Optics ($2.6 million). Lightwave technology is the basis for current and future communications and computer systems. Competition is intense in the international market for fiber optic components—currently $2.5 billion a year and expected to reach $11 billion by the year 2000. This increase would bring the total funding available in FY 1990 to $4.7 million and would enable NIST to provide the measurement capability that U.S. industry needs to develop and sell more competitive optoelectronic components in the world market.

High-Temperature Superconductors ($700,000). International competition to develop and market superconducting products is unprecedented. This increase would bring the total available in FY 1990 to $3.5 million for NIST to conduct a research program as specified in the President's Super-

conductivity Initiative. The initiative called for NIST to develop measurement methods, Standard Reference Materials, and supporting data as well as devices for measuring weak magnetic fields. In addition, it called for NIST to establish a superconductivity center for electronic applications. The center is operating now at NIST laboratories in Boulder, Colo. NIST already has made many contributions including implementing the first superconducting electronic device capable of operating at liquid nitrogen temperatures and fully characterized as a measurement device.

Bioprocess Engineering ($2.3 million). The United States currently leads the world in fundamental biochemical research and innovation in the laboratory, but is behind in the world competition to get the technology to the marketplace. The NIST program would focus on providing U.S. industry with the measurement foundation needed to facilitate manufacture of products from microorganisms and animal and plant cells in commercial quantities at low cost. In particular, areas of proposed research include monitoring and control of bioreactors, commercial separation and purification of bioproducts, measuring thermophysical properties needed for design, and identifying and characterizing the relationship between molecular structure and conformation and chemical process behavior of biomolecules. This funding would bring the total available for this research in FY 1990 to $3.7 million.

Computer Security ($3.5 million). The Computer Security Act of 1987 (P.L. 100-235) gives NIST the primary responsibility for developing standards and guidelines needed to secure sensitive, unclassified information in federal computer systems. The addition of these funds would make a total of $6 million available in FY 1990. Planned areas of research include security architecture and standards for networks, methods and standards for securing database systems, and uniform personal identification and authentication methods. These standards, guidelines, and methods will help assure that data are processed correctly and are available when needed and that only those authorized have access.

Scientific Computing Upgrade ($3.1 million). These funds have been requested to upgrade the scientific computing system used by both NIST and the National Oceanic and Atmospheric Administration, another Commerce Department agency.

■ Also included in the 1990 budget are several proposed decreases.

Industrial Technology Grants (–$7.5 million). NIST plays an important role in facilitating the transfer and effective use of technology. The establishment of the Industrial Technology Grants program, however, has introduced a large, new activity to NIST that is a significant departure from its ongoing work as a laboratory-based research facility. The Administration supports additional funding for key research efforts undertaken to fulfill NIST's traditional role and to further facilitate technology transfer, but is opposed to expansion of the grants program.

Center for Integrated Design, Nondestructive Evaluation and Manufacturing (–$7.5 million). NIST received a special appropriation of $7.5 million in its FY 1989 budget to fund the new center at Iowa State University over a 3-year period.

Fire and Building Safety Research (–$3.9 million). The fire and building safety research programs at NIST would receive $5 million and continue, although in some cases at reduced levels, NIST's efforts directly addressing safety such as work on earthquake hazards, structural safety and engineering, fire modeling, and studies on the toxicity of combustion products.

Other decreases include non-energy related inventions (–$150,000), fire research on ignition of upholstery and general toxicity studies (–$250,000), and alternative refrigerants (–$250,000).

by Jan Kosko
NIST Public Affairs Specialist

Quest for Quality

Quality products and services sell—at home and abroad. Those sales by U.S. companies help reduce the nation's trade deficit. In fact, strategic planning for quality and quality improvement programs is becoming essential to the strength of the nation's economy and the ability of U.S. companies to compete in the global marketplace.

Recognizing the critical role of quality to business, Congress created the Malcolm Baldrige National Quality Award. This award honors American companies that achieve the highest level of total quality management. Named after former Secretary of Commerce Malcolm Baldrige, the award was established by legislation—the Malcolm Baldrige National Quality Improvement Act of 1987—that was passed in August 1987.

Malcolm Baldrige National Quality Award

Presented annually, the award is intended to help motivate U.S. companies—both large and small—to improve their total quality management, including the quality of their products and services. The award was presented for the first time at a White House ceremony in November 1988. (See box on page 17.)

The National Institute of Standards and Technology manages the award program. NIST's role is a natural extension of the mission that has guided the Institute since its founding in 1901—help industry improve quality through measurement.

That effort continues through such research programs as the Automated Manufacturing Research Facility, which attempts to improve the quality of products through in-process control monitoring, and materials work in polymers, ceramics, and metals as well as basic measurement services, such as calibrations and reference materials.

The NIST quality award staff, headed by Curt W. Reimann, Associate Director for Quality Programs at the Institute, work with experts in the private sector to establish the award criteria and procedures, staff the board of examiners, and develop a course to prepare examiners for the evaluation of applications submitted for the award.

In particular, NIST staff have worked extensively with a consortium of the American Society for Quality Control and the American Productivity and Quality Center. Funding for the program comes from application fees and the private Malcolm Baldrige National Quality Award Foundation.

Almost 20,000 applications—which also serve as guidelines for a comprehensive quality program—have been distributed in connection with the second round of awards, to be presented in November 1989. Reimann is the first to admit surprise at the heightened awareness among corporations after the initial year's effort at publicizing the award. He attributes the success at reaching target audiences to the

close networks of companies and suppliers.

"As big companies learn about the program and begin to say 'We like this idea; this is useful,' they encourage their suppliers to get interested," explains Reimann.

A prime incentive for any business to pursue quality is the way it shows up on the firm's profit and loss statement. "Put your money into quality improvement. There are few things a company can do that pay as large a dividend," says Reimann. "People in the more heads-up companies are fully aware that quality now plays a significant role in the international marketplace."

The award guidelines are also catching on as a value system, a checklist for any company seriously pursuing quality. Explains Reimann, "We find companies actively using this material, ordering the guidelines in quantity, and passing them along to line managers. A number of companies have even asked for permission to reproduce them." Companies just getting started in quality can review the guidelines document and come away with a strong sense of what they ought to be doing. In effect, they have a checklist for quality.

The decision to make the application guidelines both an examination and an evaluation was a conscious one. In designing the program, the public and private sector awards committee posed questions aimed at specific areas important to quality, such as executive leadership and human resources.

According to Reimann, experts believe quality is driven by strong leadership, which creates a sustained and visible role for quality in the whole corporate fabric. Under the category "leadership," which is one of seven areas examined, the guidelines request details about the extent of personal involvement by the senior executives in quality-related activities. And they spell out the types of activities: assessing and reviewing quality plans and progress; giving and receiving training and recognition; and learning about the quality of domestic and international competitors.

The application also asks for a brief summary of the company's policy mission that demonstrates quality values. This item reflects the view of quality experts working with Reimann that unless there is visible and sustained leadership from the executive and unless there is a quality

The First Winners

Former President Reagan announced the first winners of the Malcolm Baldrige National Quality Award on November 14, 1988, during a ceremony at the White House:

- Motorola Inc.;
- Commercial Nuclear Fuel Division of Westinghouse Electric Corp.; and
- Globe Metallurgical, Inc.

Motorola Inc. has been recognized for its success in rediscovering the critical role of the customer in demanding perfection. The company's fundamental objective is total customer satisfaction through quality improvement. Its Six Sigma Quality program sets a goal of only 3.4 defects per million products. To achieve this, Motorola made statistical technologies a part of every employee's job.

The commitment to total quality for the Commercial Nuclear Fuel Division of Westinghouse Electric Corp. results from what its chairman terms "a cultural change," that is, embracing quality as a way of life. The company developed a method to monitor continuously 60 key quality areas called pulse points—from customer satisfaction to product performance.

Globe Metallurgical, Inc., a small company of 210 employees, has become the lowest cost, highest quality producer of ferroalloys and silicon metals in the United States. The company attempts to monitor and quantify every factor that influences product quality, making extensive use of computer-controlled systems that continually advise workers whether targets are met.

Curt W. Reimann explains the application process for the Malcolm Baldrige National Quality Award.

policy that pervades the organization, quality will not take hold.

"Through the quality program, we've been able to pull together an operating definition with an associated value system. The national award encourages people to look at just what this value system is in a way not possible without the existence of an award," adds Reimann.

Beyond the award program, Reimann has set some long-term goals on quality. One is to make the award a focal point for economic and business studies. He feels that one of the barriers to more scholarly studies on quality is that quality is largely undefined.

"The field must be elevated. Executives must be able to talk about it more intelligently rather than reciting phrases like quality, quality improvement, and total quality management," stresses Reimann.

He already sees that happening as fellow committee members begin to use the quality criteria in business schools.

"This approach to quality is catching on quickly," says Reimann. "The award drives a national awareness campaign. Businesses begin to take note and take interest. And business school professors who interact in the same communities as senior business leaders begin to realize the substance in this issue. They adopt the framework, and, indeed, contribute to the framework. It amounts to a social movement. That's the ultimate goal. I think we're moving in the right direction."

by John Makulowich
NIST Public Affairs Specialist

To Apply

The deadline for the 1989 award applications is May 5, 1989. Application review and site visits will take place from May 5 through September 30. The winners will be announced at an awards ceremony in November.

All applications are confidential and applicants are not expected to provide proprietary information on products or processes. An application fee of $2,000 for large companies and $1,200 for small companies recovers the costs of review.

Two awards may be given in each of three categories: manufacturing companies or subsidiaries; service companies or subsidiaries; and small business. Businesses incorporated and located in the United States may compete for the award. Subsidiaries—divisions or business units of larger companies—must primarily serve either the public or businesses other than the parent company. Small businesses are independently owned with not more than 500 full-time employees.

To receive a copy of the application guidelines, write or call: Malcolm Baldrige National Quality Award Office, NIST, Gaithersburg, MD 20899, 301/975-2036.

Too Hot To Handle, But Not To Measure

Imagine trying to measure the melting point of graphite, an important material in rocket casings and chemical process equipment. You steadily increase the temperature of your sample. Suddenly, as you approach its melting point—POOF!—it's gone. What happened? Graphite evaporates at extremely high temperature and atmospheric pressure. A National Institute of Standards and Technology researcher, Ared Cezairliyan, has developed a technique to avoid that problem. He designed and successfully operated a measuring system that will allow investigation of materials properties at temperatures ranging from 1300 K to 6000 K. Even 10,000 K is within reach of the system.

The practical applications of such research include space-related work, where temperatures soar during reentry, nuclear reactor safety, and defense—specifically rocketry, in which the nose cone as well as the skin gets very hot.

"The principle of the method is very simple," explains Cezairliyan. "Just pass high currents through the sample. Let it increase in temperature through resistive heating. Then make the electrical and thermal measurements."

The secret to the system, which took 10 years to design, develop, construct, and make operational, is extremely rapid measurements, taken in microseconds (millionths of a second). Also noteworthy is the system's high-speed temperature measurements using a photoelectric technique.

"The measurement technique is unique. We do everything quickly because the high-temperature environment is quite hostile. If you conduct the experiment in a very, very short time, many measurement problems associated with hostile environments, while still present, are minimized," says Cezairliyan.

As a byproduct of his work, the measurements that Cezairliyan and his coworkers are making contribute to the fundamentals of materials behavior. Thus, the data gathered are good input to theoreticians in understanding materials.

A sense of the system's speed dawns with the realization that the experiment is over within 100 microseconds. The temperature of the sample, which is 1.5 millimeters in diameter and 2 to 3 centimeters long, is raised by passing high currents utilizing a capacitor discharge.

The speed at which the measurements are taken yields a positive side effect—the introduction of another variable, time. This allows researchers to see how materials change with time and becomes a new parameter, like temperature, pressure, or wavelength, for example.

Using the system, Cezairliyan intends to perform research on several important thermophysical properties. These include heat capacity, electrical resistivity, thermal emissivity, thermal expansion, melting point, heat of fusion, and the velocity of sound.

Cezairliyan points out that the first accurate dynamic measurements of thermal properties at high temperatures were made in the same NIST laboratory. It is still the only one in the world with such broad and accurate capabilities. While parts of the system are available in a few other countries, the laboratory at NIST is at the frontier of new developments. *J.M.*

The Beauty of Time

Time is many things to many people. But is it beautiful? Ask some physicists at the National Institute of Standards and Technology in Boulder, Colo., and they will reply with a resounding "yes!" Forget wall clocks and digital watches; forget chronometers and sundials. For these dedicated researchers time has become atoms that dance in laser light. And, to them, that is beauty.

From their book-cluttered offices and colorful laser laboratories, they are producing a new standard of timekeeping—and blazing new trails in physics. When they get through, perhaps in a decade, their "clocks" will keep such stable time that they will neither gain nor lose a second in 10 billion years, or roughly the age of the universe. It is termed—appropriately—atomic time.

All clocks ultimately depend upon the counting of a periodic event. In a pendulum clock, for example, one full swing of the pendulum accounts for 1 second of elapsed time. With atomic clocks, the swing of the pendulum is replaced by the oscillations—or vibrations—of a particular atom.

The measurement of time changed forever on January 6, 1949, when NIST unveiled the world's first atomic clock. It counted the oscillations of microwaves required to change the energy state of the nitrogen atom in the ammonia molecule. Since the resonant frequencies of atoms never vary, the atomic clock would keep time with great stability—1 second in 3 years.

Physicist Wayne Itano adjusts an external cavity frequency doubler, which is part of a laser setup for the mercury ion clock experiment.

Physicists had known for years that an atom stimulated by an outside influence such as microwaves "jumped" to a higher level of energy. When the frequency of the applied radiation matched that needed to raise the atom to the higher energy level, the resonance condition was achieved. By counting this frequency, a measure of time was obtainable. Over the years, NIST scientists have improved on this method. Atomic time is now measured officially by electronically "locking" high-frequency microwaves to a resonant frequency of the cesium atom. This provides a clock that neither gains nor loses a second in 300,000 years.

The advent and perfection of lasers has allowed NIST scien-

tists to progress to a new timekeeping plateau. Lasers emit streams of photons which are absorbed by the atoms (or by electrically charged atoms called ions), cooling them, and causing them to slow down. In fact, the technique has been so successful that it has resulted in atoms that literally stop when confined in magnetic or electric "traps."

When cooled to the stopping point, the resonant frequencies of the ions were studied and found to be extremely well defined and stable. Once these frequencies are measured, they could become the basis for a new standard of timekeeping. NIST scientists are studying single mercury ions as likely candidates for such a new clock.

It is uncertain when this laser-cooled clock will come on line—perhaps as long as a decade. A prototype of this clock, based on the oscillations of the beryllium atom and equal in stability to the best current cesium clocks, could be functioning within 6 months. The mercury ion clock should be considerably beyond this in performance.

Donald Sullivan, chief of the NIST Time and Frequency Division, is confident that a far more accurate clock will become a reality. "There are no fundamental roadblocks; it's going to happen," he says. This clock may be based on the mercury ion.

In their quest for the super-stable atomic clock, the NIST researchers have broken new ground in physics. Since 1913 physicists had theorized that atoms moved from one energy level to another in quantum jumps, but no one had ever directly witnessed such a leap.

In research that could be the basis for a new standard of timekeeping, John Bollinger sets the optics of the system used to image fluorescence of the beryllium ion.

In their quest for the super-stable atomic clock, the NIST researchers have broken new ground in physics.

The NIST group—along with others at the University of Washington and the University of Hamburg—have actually seen these jumps, and the NIST group made computer-processed images of single and small clusters of laser-cooled mercury ions fluorescing on and off as they changed energy states.

In another leading-edge experiment, the NIST group laser-cooled a mercury ion, confined in a radio frequency "trap," to its fundamental limit. "The atom was pushed into the ground state of its confining well. That's the end of cooling for a bound particle," says Sullivan. The work is important for spectroscopy, a study of the nature of matter through various radiation it emits. One result may be a highly sensitive spectrum analyzer.

NIST staff members working on this project include James Bergquist, John Bollinger, Wayne Itano, Charles Manney, and David Wineland. *F.M.*

Cold Neutron Facility Dedicated

In January, Commerce Department officials cut the ribbon on the first U.S. facility devoted to cold neutron research. The NIST Cold Neutron Research Facility (CNRF) will give U.S. industry prime access to one of the key tools of modern materials science. "NIST has developed this new resource to share with the rest of the country," said Acting Under Secretary of Commerce for Technology Ernest Ambler.

"All the proposed experimental stations will be available for use by outside organizations."

There are at least four major centers for cold neutron research in Europe, he said, and another under construction in Japan.

Beams of neutrons, produced by nuclear research reactors, have emerged in recent years as one of the premier probes for studying the arrangement and interactions of atoms in materials. Because they interact with matter in a fundamentally different way, beams of neutrons provide a good complement to better-known infrared and x-ray techniques.

The newly constructed NIST Cold Neutron Research Facility is the first facility devoted solely to cold neutron research in the United States.

"Cold" neutrons—they are refrigerated to about –415 °F—have greatly extended the power of neutron research. Their very low kinetic energies allow researchers to conduct experiments on classes of materials that would be impractical or even impossible with higher-energy neutrons.

Typical test subjects range from semiconductor devices and high-temperature superconductors to new magnetic alloys and high-strength ceramics for lightweight, high-efficiency motors.

Neutrons are highly penetrating, which makes it possible to probe deep within materials to characterize, for example, microcracks or voids. Other common probes, such as x-rays or electron beams, can examine only relatively thin layers near the surface of materials.

In addition, neutrons interact with light elements and heavy ones with, essentially, equal sensitivity and so complement x-rays, which are more sensitive to heavy elements. Neutrons can "see" a difference between hydrogen and its chemical twin, deuterium, a fact used to great advantage in polymer, chemical, and biological research to label specific molecules in order to study their structure; x-rays cannot.

Neutrons interact in a special way with magnetic materials, and so can be used for very sophisticated studies of the properties of these materials. Neutrons probe the atomic-scale motions of all materials in a way unmatched by any other technique.

Applications for intense cold neutron beams exist in virtually every branch of materials research. For example, a cold neutron source can be used to:

- study the microstructure of new, high-temperature superconductors.
- investigate the magnetic properties of new, advanced alloys. As an example, new magnetic alloys are being developed

for use in power transformers and small motors, which promise major savings in the cost of power generation and automobile components.

- measure the growth of cracks or the nature of voids in new, experimental ceramics. The use of high-temperature ceramics in automobile engines, for example, could mean a 30-percent increase in efficiency.
- study the distribution of "doping" elements in semiconductor materials in concentrations below 1 part in a million. This is a critical factor in improved process control for the semiconductor industry.
- allow the tailoring of new catalytic materials for use in "cracking" crude oils and producing specialty chemicals. Cold neutron beams make it possible to observe the movement of molecules which control chemical reaction or selection.
- measure the size and shape of "engineered" biomolecules in their natural environments as changes occur. Such a capability is of major importance to the growing biotechnology industry.

The first instruments to be installed in the new facility will include:

- a high-resolution, 30-meter small-angle neutron scattering (SANS) spectrometer—a fundamental tool of neutron research, which will rank with the best in the world;
- the best neutron depth-profiling instrument in the world, a tool particularly useful to the semiconductor industry;
- a prompt-gamma-ray activation analysis station for "real-time" elemental analysis—this and the depth-profiling instrument will make up the best facility in the world for the chemical analysis of materials with neutron beams; and

"All the proposed experimental stations will be available for use by outside organizations."

- two interim instruments: a medium-resolution 8-meter SANS spectrometer and a time-of-flight spectrometer. The latter is used to study molecular motions and interactions, which are a key to understanding chemical absorption, diffusion, or catalysis.

At least three of these instruments will be available within a year.

As a result of a recently concluded agreement, the National Science Foundation will sponsor the construction of a Center for High-Resolution Neutron Scattering at the CNRF. It will consist of a second 30-meter SANS spectrometer and a unique spin-polarized inelastic neutron scattering (SPINS) spectrometer. These instruments should be available to the U.S. research community within 2 and 3 years respectively.

Other instruments are under design. Ultimately, the center will include 15 experimental stations: 10 will be instrumented and operated by NIST and 5 will be instrumented and operated by outside groups. These Participating Research Teams (PRT's) will come from industrial, academic, or government research institutions and will fully instrument and maintain their stations in return for exclusive use of 75 percent of the available research time.

The high-resolution SANS spectrometer is being constructed by a PRT consisting of NIST and Exxon Research and Engineering. Eastman Kodak Company has provided support for the construction of several of the instrurnents, in particular the neutron depth profiling station.

One-quarter of the available research time on the stations instrumented by PRT's and two-thirds of the time on the NIST stations will be made available to the general research community in the United States. An external advisory committee will be set up to handle the allocation of research time, which will be made available to all U.S. users.

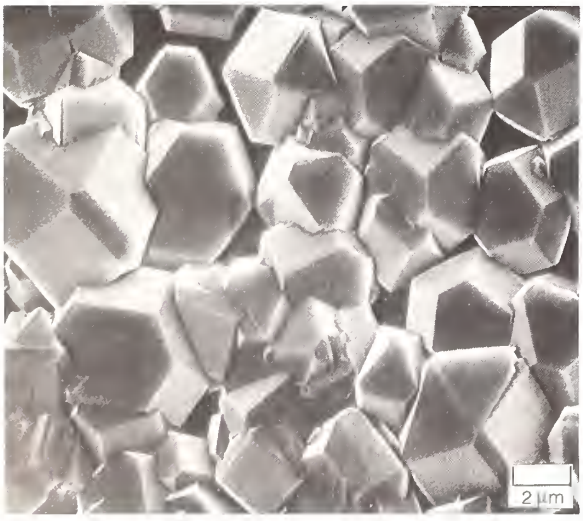
The cold neutron source at the NIST research reactor became operational in the fall of 1987. The research facility itself was authorized by the Congress, beginning in fiscal year 1987, at a level of $6.5 million per year. The direct appropriation for the first year was $4.5 million. In fiscal years 1988 and 1989, $6.5 million has been appropriated. The total construction cost of the facility is estimated at $25 million.

by Michael Baum
NIST Public Affairs Specialist

Diamond Films: New Gems in Advanced Materials

Ancient alchemists did not succeed in changing base metals into gold, but scientists today are able to produce synthetic diamonds from common organic materials. With modern technology, hydrocarbon vapors mixed with hydrogen can be made to deposit a film of diamond on hot objects. While it would be impossible to produce jewelry with this process, these synthetic diamonds have the same crystal structure as natural gemstones.

Materials scientists at the National Institute of Standards and Technology are developing the measurement information industry needs to produce diamond films with many of the properties of natural diamond. The physical and chemical properties of diamond make it a highly desirable material for aerospace products, electronics, and industrial equipment.



Diamond particles are shown merging into a continuous film in this micrograph.

Diamond is the hardest known natural material. It has the highest thermal conductivity, and it has very high electrical insulation characteristics. Diamond also is optically transparent and chemically stable or inert under most conditions.

Albert Feldman, leader of the NIST optical materials group, points out that diamond films can play an important role in many advanced technologies. For example, diamond would be an excellent window material in anti-missile defense systems equipped with high-powered lasers. The thermal conductivity of diamond will allow it to dissipate heat rapidly and eliminate hot spots, says Feldman.

Other examples include high-temperature diamond transistors that would largely replace conventional electronic devices in unmanned spacecraft. Many of these conventional components require cooling systems that typically occupy up to 60 percent of the volume of the satellite.

Diamond film substrates in electronic chips can improve the efficiency of computers by permitting a higher density of components because diamond dissipates heat faster than other materials. Diamond also has potential for microwave power generation because it can carry electric charges at high velocities without suffering a breakdown in performance at the high voltages required.

Industrial applications for diamond films include coatings to resist corrosion in chemical storage containers, to reduce friction and wear on machines and cutting tools, and to protect optical lenses from surface scratches.

Feldman says, "Our research objective is to characterize the production processes, the structures, and other properties of diamond films to help industry produce high-quality, high-performance advanced materials."

At NIST, the scientists are evaluating the production of diamond films by a hot filament chemical vapor deposition (CVD) method. With the CVD process, an object is placed inside a low-pressure chamber and heated to approximately 800 °C. A tungsten filament at the top of the chamber is heated to approximately 1800 °C. As a gas mixture of approximately 0.5 percent methane and 99.5 hydrogen flows over the "white hot" filament, it undergoes a chemical reaction to form reactive hydrocarbon vapors. These vapors react with the heated object, which then becomes coated with diamond.

The NIST researchers are using a variety of analytical techniques to evaluate the synthesized diamond crystals on various materials. The tools include Raman spectroscopy, a light-scattering technique to determine the purity of diamond; Auger electron microscopy to measure the surface quality of diamond films; scanning electron microscopy to study the physical shape or morphology of diamond crystals; and x-ray diffraction to evaluate the crystal structure of diamond.

In addition, they are using cathodoluminescence imaging and spectroscopy in a scanning electron microscope. This light-emitting technique identifies defects and their distribution on a micrometer scale in diamond films.

Feldman and his colleagues are measuring the thermal conductivity of diamond, particularly for optical applications like the windows for anti-missile systems and for optoelectronics such as ultraviolet detectors. They also will work to develop a better understanding of how defects, such as nitrogen impurities and crystal lattice vacancies or voids, can affect the performance of diamond films.

The scientists are concerned about differences in the thermal expansion of various substrates and diamond as they cool during processing. This can lead to stress, fracture, and the delamination of films. The substrate materials under investigation are silicon, silicon carbide, and mullite—a silicate of aluminum with similar thermal expansion properties to diamond.

Future plans call for studies on how the crystal structure of each substrate material affects the growth and orientation of diamond crystals. Epitaxial growth in which the crystal structure of the diamond film is in perfect alignment with the crystal structure of the substrate would represent a significant breakthrough for electronic applications, says Feldman.

Edward Farabaugh (left) and Albert Feldman use the hot filament chemical vapor deposition method to deposit a diamond film on a silicon carbide sphere.

by Roger Rensberger
NIST Public Affairs Specialist

Fracture Test on Thick Steel Plate Sets U.S. Record

Just how tough is a 6-inch-thick piece of steel? Ask Richard J. Fields, project manager for a series of tests on thick steel plates that were performed to learn more about how cracks might travel and stop in large pieces of metal. Fields and a team of scientists at the National Institute of Standards and Technology learned that it took 5.94 million pounds of force in tension—pulling force—to fracture a 6-inch-thick, 40-inch-wide new steel plate. According to Fields, this represents a U.S. record for fracture tests.

Fields says, "It is unlikely that a higher load fracture test will be performed in the NIST test facility because the machine is rated for only 6 million pounds in tension—only 1 percent more than the actual test load. To our knowledge, this was the largest, controlled tensile test to be conducted in the United States."

The record fracture test was carried out on the NIST 12-million-pound-force Universal Testing Machine, the largest operating device of its type in the nation. This special apparatus, rising 80 feet above the ground, is used to pull or compress materials to failure. The machine is capable of producing 6 million pounds force in tension or 12 million pounds force in compression. These forces can be applied to full-scale test structures such as bridge columns or large material specimens like the thick steel plate.

The wide-plate, crack-arrest tests were conducted by NIST to obtain new information on the performance of thick steels. Existing standards, according to Fields, are based in part on information extrapolated from small-scale laboratory fracture measurements—known as "Charpy tests"—made with centimeter-sized material specimens. New information from the NIST wide-plate tests will help to assess how conservative the current standards are.

For the large-scale fracture experiment, the test material was specially prepared to predetermine the location of the fracture. The steel specimen had an 8-inch notch through the plate, cut into the material at the outside edge. A sharp crack was made from one outer surface to the other in the notch. There also was a face groove across the surface of the plate to guide the crack under stress.

The test material then was welded to heavy steel pull-plates to form a 35-foot-long "dogbone-shaped" test assembly that weighed approximately 26,000 pounds. The overall dimensions of the test specimen were designed to take advantage of the high load capability and large dimensional capacity of the NIST Universal Testing Machine.

"To our knowledge, this was the largest, controlled tensile test to be conducted in the United States."

After being mounted vertically in the test apparatus, the notched edge of the steel plate was cooled to below –100 °C and the other edge was heated to approximately +200 °C. The test plate was then pulled until fracture occurred under 5.94 million pounds force in tension.

Fields explains that metallurgists know that cold steels are relatively less tough and more susceptible to crack propagation than warm, ductile steels. The thick steel plate used in the NIST test was cooled at the notched edge and heated at the other to cause a brittle crack to start running at more than 500 meters per second (over 1200 mph) and then stop in the warmer, very tough material.

He also notes that in order to measure correctly the speed of a crack in tests of this type, the test specimen had to be 10 times longer than it was wide to avoid the distorting effects of reflected stress waves that travel between 5 and 10 times faster than the actual crack.

Fields says, "We had approximately 2 milliseconds in which to measure crack velocity before the stress waves returned from the ends of the 35-foot-long test specimen."

With special high-speed instrumentation, the scientists were able to measure the speed of the brittle crack as it moved through the test specimen, determine when the crack stopped or "arrested," and identify the temperature where ductile behavior—fibrous tearing of the thick steel—began and led to the final stage where the material was pulled apart.

Other fracture experiments at NIST have included tests on thick steels that were specially heat-treated to modify their microstructures. This treatment produces a low-toughness material that is similar to steels exposed to high temperatures and other harsh conditions in various industrial environments.

In addition to extending the limits of existing data on crack arrest, Fields points out that the NIST scientists aim to establish clearly that brittle cracks stop before ductile fracture or slow crack growth begins. Information from the tests also can be used to improve fracture models and experimental methods, says Fields.

Roland deWit, assistant project manager, points out that the results from the NIST experiments may be used to revise industry codes and standards. New information will be useful in the design of all types of steel structures including bridges, ships, and buildings, as well as for equipment in industrial plants and utilities, says deWit.

How tough are the thick, heavy section steels tested at NIST? Fields says, "All information so far from the wide-plate, crack-arrest tests indicates that the fracture toughness of these steels at the point of crack arrest significantly exceeds minimum values used in applicable design codes and standards." *R.R.*

Mechanical engineer Samuel R. Low stands on the platform of the Universal Testing Machine beside the midsection of a 35-foot-long test specimen with an insert of special thick steel plates.

New Dental Bonding System Licensed

A simplified adhesive bonding system for restoring teeth is closer to the marketplace as a result of a new license granted to a U.S. manufacturer. The improved system for bonding dental resins to hard tooth tissues—both dentin and enamel simultaneously—was developed in the Paffenbarger Research Center (PRC) at the National Institute of Standards and Technology.

The new two-step method was licensed under a domestic agreement to Myron International, Inc., a Kansas City, Kan., dental materials manufacturer and distributor, by the American Dental Association Health Foundation (ADAHF), the sponsor of the 60-year-old research program at NIST.

Research scientist Fred Eichmiller and research associate Agnes Ly test a new adhesive bonding system on a patient at the Paffenbarger Research Center.

Rafael L. Bowen, director of the PRC, points out that the new system is a two-step clinical method that simplifies a multistep procedure developed at the research center in 1981. The new system permits dentists to do a better job in conserving tooth structures, rebuilding badly damaged teeth, and making cosmetic improvements to front teeth, says Bowen.

He also points out that in addition to reducing the amount of tooth structure that must be cut away for the retention of restorative composites, adhesive bonding methods increase patient comfort during and after dental procedures.

The new system requires the treatment area to be conditioned with an acidic N-phenylglycine solution for about 60 seconds. After the surface is blown dry, the area is painted with a solution of PMDM (the reaction product of pyromellitic dianhydride and 2-hydroxyethyl methacrylate) and allowed to dry for 30 to 60 seconds. Then the surface is ready for the application of a composite restorative material. The surface treatment also can be used with resins to bond porcelain and cast ceramic restorations.

Roger M. Sigler, president of Myron International, says, "The opportunity to work with Dr. Bowen and the researchers at NIST has been a real privilege. We truly believe this new technical breakthrough will revolutionize the dental profession."

John A. Tesk, leader of the NIST dental and medical materials group, says, "The new bonding method is a result of our efforts to support research on the safe, efficient, and economical use of materials to benefit consumers, the practicing dental professional, and American industry. This also shows how we can support the competitive

position of U.S. dental materials companies in international markets."

The new two-step method is the latest in the long series of projects with industry and government that have been conducted by the American Dental Association (ADA) at NIST. (See box below.)

For information on the new dentin and enamel adhesive bonding system (Mirage-Bond–registered trademark of Myron International), contact: Myron International, Inc., 200 N. 6th Street, Kansas City, KS 66101, 800/255-4620. *R.R.*

A Model of Collaboration

The dental materials program at NIST is a long-standing model of cooperation between the private sector and government. It involves approximately 45 dental scientists from NIST's Polymers Division, the American Dental Association, the National Institute of Dental Research (NIDR), the dental materials industry, and leading universities in the dental field.

The first dental materials research project at NIST, then the National Bureau of Standards, was done for the U.S. Army Dental Corps in 1919. The Army asked for assistance in writing a bid request for amalgam—metal dental filling material—that could be based on some physical property measurements.

After studying the amalgam materials available, the researchers published a report in 1920 on the basic properties and characteristics of amalgams. The report, which had an immediate influence on the manufacture of alloys for amalgams, provided dentists with the first unbiased source of information on the materials.

In 1928 the ADA and NIST embarked upon a collaborative research program that continues to this day. In this program, ADA pays scientists to work at NIST on projects of mutual interest; for example, they are studying new ways to bond composite materials to teeth and bone and analytical methods to learn more about the causes of dental disease.

Researchers have made improvements in the durability of composites and resins used in tooth restorations and developed spherical alloys for amalgams. Other contributions to the practice of dentistry include the panoramic x-ray and the water turbine contra-angle dental drill, which was later refined into today's air-driven drill. In addition to increasing the quality of patient care, both of these instruments have saved the nation several billion dollars since they were introduced by reducing the time required by dentists to treat patients while increasing the comfort and effectiveness of dental treatment. One offshoot of the 61-year collaboration has resulted in approximately 50 specifications for dental materials, instruments, and equipment.

NIDR also sponsors researchers to work at NIST to study the chemistry of calcium compounds and how they relate to living systems. NIDR scientists are interested in combining their biologically oriented work with NIST chemical research on calcium phosphate compounds. Their goal is to develop new treatments for diseases of the teeth and skeletal system.

Other organizations that recently have sponsored researchers at NIST include Dentsply International, Astron Corp., the Royal Dental College, Georgetown University, The University of Maryland, Nihon University, Tokushima University School of Dentistry, Tokyo Medical and Dental University, and the U.S. Naval Dental Clinic.

Johnson and Johnson, Pentron Corp., Austenal Dental Laboratories, Williams Gold Refining Co., Whip Mix Corp., Howmedica Inc., and Genex also have provided support to the program.

New Publications

Facilities of the National Institute of Standards and Technology

Public Information Division, Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 732, 36 pages (September 1988). Order by sending a self-addressed mailing label to the Office of Research and Technology Applications, NIST, A537 Administration Bldg., Gaithersburg, MD 20899.

Need a laboratory for measuring high voltage? How about an ultra-clean room for ceramics processing? Or maybe a transverse electromagnetic cell? This brochure describes these and many other research and testing facilities at NIST laboratories in Gaithersburg, Md. and Boulder, Colo. These NIST facilities—some unequaled anywhere in the world—are available through different programs to qualified individuals and organizations for collaborative or independent proprietary research. The NIST Research Associate Program enables sponsoring organizations to pay researchers' salaries while NIST contributes its expertise and allows use of its equipment.

NIST Calibration Services Users Guide 1989

Simmons, J.D., editor, Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 250, 186 pages (January 1989). Order from the Office of Physical Measurement Services, NIST, B362 Physics Bldg., Gaithersburg, MD 20899, 301/975-2005.

This new guide lists the calibration services, special test services, and measurement assurance programs (MAP's) available from NIST. These physical measurement services are designed to help the makers and users of precision measurements achieve the highest possible levels of measurement quality and productivity. The hundreds of individual services described in this guide are the most accurate calibrations of their type available in the United States. They directly link a customer's precision equipment or transfer standards to national measurement standards. The calibrations and special tests include NIST services that check, adjust, or characterize instruments, devices, and sets of standards. The MAP's are quality control programs for calibrating a customer's entire measurement system. The guide also lists NIST technical experts who may be contacted for information on services and measurement problems.

Energy-Related Inventions Program: A Joint Program of the Department of Energy and the National Institute of Standards and Technology—Status Report

Hart, F.L., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 88-4005, 307 pages (October 1988). Order by stock no. PB 89-141154 from NTIS, $36.95 prepaid.

A portable pothole patcher, a new composite material made of high-strength fibers, a new process for continuous casting of steel cylinders, and a lightweight aluminum cylinder which makes it practical to use natural gas as a vehicle fuel are among the 400-plus inventions to receive support from the federal Energy-Related Inventions Program. The program, which began in 1975, is conducted jointly by NIST and the U.S. Department of Energy and aims at helping inventors get their ideas from the workshop to the marketplace. NIST provides, at no cost to the inventor, evaluations of energy-related inventions and recommends those it considers promising to DOE. In turn, DOE can provide financial support or help in marketing an inventor's idea. This report describes the program as well as the inventions which have been recommended for DOE support.

High-Temperature Superconductivity: Abstracts of NIST Publications, 1987-1988

DeWeese, M.E., Kamper, R.A., and Powell, R.M., editors, Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 759, 35 pages (November 1988). Order by stock no. 003-003-02902-5 from GPO, $2 prepaid.

With the discovery of high-temperature superconductors came the need to extend research from metals to ceramics, for which NIST was well prepared. NIST has an established program in ceramics and an extensive array of facilities to analyze and map the composition, structure, and electronic energy spectrum of materials in a wide range of scales. This collection of 61 abstracts represents the first results of applying all these resources to high-temperature superconductors. Many of the papers have authors from several institutions. NIST encourages collaborative research projects to maximize the benefit of its resources to the U.S. research and development community.

Center for Analytical Chemistry—1988 Technical Activities

Hertz, H.S., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 88-3875, 177 pages (November 1988). Order free from the Center for Analytical Chemistry, NIST, A309 Chemistry Bldg., Gaithersburg, MD 20899, 301/975-3145.

The measurement of trace elements in the human diet, tools to improve urine tests for drug abuse, and accuracy improvements in the radiocarbon dating of fossil bones are

just a few of the 74 projects described in this report. It spotlights the important role NIST analytical chemistry work plays in providing data for highly complex sample types—samples such as hazardous chemicals, body fluids, plant and animal tissues, foods, and high-technology materials. Significant publications and activities are listed, along with tallies of analytical chemistry Standard Reference Materials that NIST produced in 1988.

Preliminary Performance Criteria for Building Materials, Equipment and Systems Used in Detention and Correctional Facilities

Dikkers, R.D., Husmann, R.J., Webster, J.H., Sorg, J.P., and Holmes, R.A., Natl. Inst. Stand. & Tech. (U.S.), NISTIR 89-4027, 172 pages (January 1989). Order by stock no. PB 89-1148514 from NTIS, $21.95 prepaid.

A rapid increase in construction of new prisons in the United States is taking place to supplement existing overcrowded, aging, and deteriorating facilities. Over $1.5 billion was spent to build new jails and prisons in both 1985 and 1986. But little specific information exists on the special materials, equipment, and systems used in these facilities. As a result, many correctional agencies have experienced equipment and system performance problems leading to expensive retrofits or repairs. In a project for the U.S. Department of Justice, NIST researchers have developed preliminary performance criteria to help in the selection, application, and maintenance of building materials, equipment, and systems. This report covers such criteria as choosing a site, selecting appropriate fencing and intrusion detection systems, and developing structural systems.

Technical Digest, Symposium on Optical Fiber Measurements, 1988

Day, G.W. and Franzen, D.L., editors, Natl. Inst. Stand. & Tech. (U.S.), NIST Spec. Pub. 748, 202 pages (September 1988). Order by stock no. 003-003-02878-9 from GPO, $10 prepaid.

Researchers interested in advances in optical fiber measurements will benefit from this publication. It contains the summaries of all 42 papers presented at the fifth biennial Symposium on Optical Fiber Measurements, held at NIST's Boulder, Colo., laboratories in September 1988. Of particular interest are papers on optical time domain reflectometry, the measurement of cut-off wavelength, and the characterization of planar optical waveguides.

NBS Handbook 44-1989, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

Oppermann, H.V., editor, Natl. Bur. Stand. (U.S.), NBS Hdbk. 44-1989, 277 pages (September 1988). Order by stock no. 003-003-02888-6 from GPO, $16 prepaid.

NBS Handbook 130-1989, Uniform Laws and Regulations

Brickenkamp, C.S., editor, Natl. Bur. Stand. (U.S.), NBS Hdbk. 130-1989, 201 pages (September 1988). Order by stock no. 003-003-02890-8 from GPO, $11 prepaid.

NBS Handbook 133-Third Edition, Checking the Net Contents of Packaged Goods

Brickenkamp, C.S., Hasko, S., and Natrella, M.G., editors, Natl. Bur. Stand. (U.S.), NBS Hdbk. 133-Third Edition, 305 pages (September 1988). Order by stock no. 003-003-02885-1 from GPO, $16 prepaid.

All three of these handbooks have been revised by NIST to reflect changes adopted at the 73rd annual meeting of the National Conference on Weights and Measures (NCWM) held in July 1988. NCWM, an organization of state, county, and city weights and measures enforcement officials, receives technical support from NIST through its Office of Weights and Measures.

The major changes to NBS Handbook 44-1989 include a revised section on liquid measuring devices to clarify the code for use by field inspectors; a new set of requirements for identifying the "concentrated load capacity" of large scales such as those used to weigh vehicles; and new marking requirements for grain moisture meters.

A new definition for net weight has been added to NBS Handbook 130-1989. Also included are a reference to ASTM D4814 Standard Specification for Spark-Ignition Engine Fuel, a clarification to the method of sale for seafood, and an amendment to variations from declared thickness for polyethylene products.

New inspection procedures that recognize moisture loss in packaged meat and poultry during the course of good distribution practices have been added to NBS Handbook 133.

Ordering Information

To order publications from NTIS, send request with payment to: National Technical Information Service, Springfield, VA 22161. Publications can be ordered from GPO by mailing the order with payment to Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Conference Calendar

SECOND INTERNATIONAL CONFERENCE ON CHEMICAL KINETICS

NIST, Gaithersburg, MD

Leading individuals from universities, research laboratories, and industrial organizations will review the progress and problems of current interest in the measurement, evaluation, and application of fundamental chemical kinetic data to the analysis of complex chemical processes. The conference will focus on those areas of science and technology in which modeling is used successfully to explain and predict complex phenomena. Subject areas include: atmospheric chemistry, acid deposition, combustion chemistry, chemistry of energetic materials, plasma processing, analytical chemistry, and modeling studies of complex systems. Sponsored by NIST, the Environmental Protection Agency, the National Aeronautics and Space Administration, the American Chemical Society, the Petroleum Research Fund, the Gas Research Institute, the National Science Foundation, and the Ford Motor Company. Contact: Rhoda Levin, A267 Chemistry Bldg., NIST, Gaithersburg, MD 20899, 301/975-2575.

16TH INTERNATIONAL CONFERENCE ON THE PHYSICS OF ELECTRONIC AND ATOMIC COLLISIONS

Grand Hyatt Hotel, New York, NY

This biennial international conference seeks to promote the growth of scientific knowledge and its effective exchange among investigators of all nations in the field of electronic and atomic collisions and related areas of atomic and molecular physics. The conference deals with two-body interactions between ions, atoms, molecules, electrons, positrons, and photons. It is sponsored by the International Union of Pure and Applied Physics. Cosponsored by NIST and the American Physical Society; supported in part by the Air Force Office of Scientific Research, the Office of Naval Research, the U.S. Department of Energy, the National Science Foundation, the National Aeronautics and Space Administration, and the Defense Advanced Research Projects Agency. Contact: Thomas Lucatorto, A251 Physics Bldg., NIST, Gaithersburg, MD 20899, 301/975-3734.

12TH INTERNATIONAL SYMPOSIUM ON POLYNUCLEAR AROMATIC HYDROCARBONS

NIST, Gaithersburg, MD

The major focal point for multidisciplinary research on this important class of chemical species, the symposium encourages open discussions among scientists representing government, academic institutions, industry, and research facilities investigating the chemical properties and biological effects of these compounds. The 1989 meeting will include presentations on parent hydrocarbon PAH's as well as heteroatomic species and PAH derivatives including amino, nitro, and halogen substituted compounds. Topics include adducts, bioactivity, carcinogenesis, mutagenicity, cell transformation, detoxification, epidemiology, pollution modeling, and occupational exposure. Sponsored by NIST, the National Institutes of Health, and Battelle Memorial Institute. Contact: Willie E. May, A113 Chemistry Bldg., NIST, Gaithersburg, MD 20899, 301/975-3108.

ATOMIC PROCESSES IN PLASMAS

NIST, Gaithersburg, MD

Among the subjects to be discussed at this biennial meeting of international experts are atomic processes relevant to plasma applications, such as material processing by plasmas, x-ray lasers, fusion, and astrophysics. This conference combines the series previously known as the APS Topical Conference on Atomic Processes in High-Temperature Plasmas with the International Conference/Workshop on the Radiative Properties of Hot Dense Matter. Sponsored by the American Physical Society, the Department of Energy, and NIST. Contact: Yong-Ki Kim, A267 Physics Bldg., NIST, Gaithersburg, MD 20899, 301/975-3203.

12TH COMPUTER SECURITY CONFERENCE–INFORMATION SYSTEMS SECURITY: SOLUTIONS FOR TODAY, CONCEPTS FOR TOMORROW

Baltimore Convention Center, Baltimore, MD

This conference provides a forum for users, vendors, and the research and development communities to share information technologies that are designed to meet the ever-growing challenge of telecommunications and automated information systems security. Topics will include: systems application guidance, security education and training, evaluation and certification, innovations and new products, and disaster prevention and recovery. Sponsored by NIST and the National Computer Security Center. Contact: Irene Gilbert, A254 Technology Bldg., NIST, Gaithersburg, MD 20899, 301/975-3360.

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